Codling Moth: Biotic Potential of Males and Colony Vigor of Three Laboratory Strains

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ABSTRACT

Facets of the biotic potential of males of three codling moth colonies, laboratory reared since 1960, 1973, and 1974 for approximately 156, 32, and 32 generations in colonization, respectively, were compared. Fifty-nine males from each colony were used. Parameters compared were: number of males mating, number of matings, number of matings per male, number of eggs, percent egg hatch, number of eggs per male, male longevity, and distribution and frequency of multiple matings among males. Evaluation of the findings showed that the colony begun in 1974 had a greater biotic potential than the other two colonies. This finding agrees with release-recapture studies using the 1973 and 1974 colonies.

KEYWORDS: Codling moth, biotic potential, vigor, reproductive potential, insect colonization.

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CODLING MOTH:[1] BIOTIC POTENTIAL OF MALES AND COLONY VIGOR OF THREE LABORATORY STRAINS

By Robert B. Hutt[2]

INTRODUCTION

In recent years, there has been much interest in the quality of mass-reared insects (Chambers *1975*, *1977*).[3] Boller (*1972*) and Huettel (*1976*) discussed mass rearing and its consequences to the behavior of artificially colonized insects and examined actual and possible techniques of quality control monitoring systems.

At the Yakima Agricultural Research Laboratory, we have routinely carried out quantity and quality control monitoring procedures for a number of years; however, emphasis was always given to numbers and production rate (Hathaway et al. *1973*), with only nominal interest shown for the health or vigor[4] of the colony. Little has been done in the way of quality control measurements for assessing insect vigor. Hutt and White (*1974*) reported on a simple laboratory technique for assessing some of the effects of irradiation on mating capacity; however, it did not give any indication as to the vigor of the unirradiated insects.

It is a simple matter to investigate radiation effects and show a clear picture of the impact of exposure to radiation by experimentation using irradiated and unirradiated insects from the same brood of the same strain. In codling moth work, we need a means of measuring the constitutional or genetic vigor of a particular strain and techniques for assessing the impact of artificial colonization on that vigor to evaluate the potential value of that strain as laboratory stock.

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[3] The year in italic, when it follows the author's name, refers to Literature Cited, p. 5.

[4] Vigor, as used in this publication, refers to available biological energy and efficiency of usage thereof by an individual, colony, population, or species and is expressed in terms of reproductive and nonreproductive activities.

The tests reported in this paper were not conducted concurrently; limitations of space and assistance precluded that possibility. The object of these measurements is not to look at laboratory colonies concurrently but, rather, to measure the response characteristics of a single colony at a given length of time in colonization and make some estimate of the general vigor of that colony in terms of field performance. Hopefully, we can develop a system of simple laboratory tests to discern measureable changes in laboratory response characteristics, which can be related to both changes in the magnitude of desirable characteristics of field performance and specific rearing procedures. Then, rearing technology can be altered to produce moths that perform better in the field or at least arrive at a happy medium between numbers and vigor.

With this end in mind, I measured the male biotic potential[5] of three laboratory strains of codling moths.

METHODS AND MATERIALS

The three strains of codling moths were all colonized with larvae obtained from infested fruit collected in the Yakima Valley of Washington. The colonies were begun in 1960, 1973, and 1974, and had been in colonization for 156, 32, and 32 generations, respectively, when they were tested and reared according to our standard regimen (Hamilton and Hathaway *1966*, Hathaway *1967*, Hathaway et al. *1972*, and Hutt et al. *1972*).

Virgin moths were obtained in the manner described by Hutt and White (*1972*). Newly eclosed moths were collected and sexed each morning. Twenty males were each placed singly in holding cages (White and Hutt *1971*) with a newly eclosed, 0 to 24-h-old female of the same colony. After 24 h, the male was removed from the cage and placed in another cage with another 0 to 24-h-old female. This was repeated daily until the male died. The females were held in their cages until they died. They were then dissected for spermatophores. The cages were held an additional 7 to 10 days and were then examined for oviposition and egg hatch. The cages were held at 25°C (±1°), 70-percent relative humidity (±9 percent), and 16-h photophase during the tests. Data obtained from the test were subjected to analysis of variance.

RESULTS AND DISCUSSION

Table 1 presents the results of the tests. One male from each colony died on the first day, so all of the subsequent calculations were made on the basis of 59 males. Certainly, these are whole colony measurements and involve and reflect responses by the females but are presented in terms of males for simplicity. Of the parameters measured, only total matings and matings per male showed statistically significant differences ($p = 0.05$) between the 1974 colony and the 1960 and 1973 colonies.

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[5]Biotic potential, as used in this publication, refers to the capacity to increase the biomass of a colony, population, or species and deals with reproductive capability.

Table 1.--*Parameters measured (in terms of males) by colony*

Parameters	Colony		
	1960	1973	1974
Males (number)	59.0	59.0	59.0
Males mated (number)	55	55	58
Matings (number)	233	227	273
Matings per male (number)	3.9	3.8	4.6
Eggs (number)	30,726	29,035	34,957
Hatch (percent)	77	76	77
Eggs per male (number)	521	492	592
Male longevity (days)	7.15	7.61	7.34
Males mating (number of times):			
0	4	4	1
1	0	2	1
2	6	4	0
3	9	12	8
4	16	15	15
5	15	13	20
6	8	7	11
7	1	2	1
8	0	0	2

Table 2 shows the relationship between the age of adult males in days and the number of matings for the three colonies. For first matings on day 1, second matings on day 2, and third matings on day 3, the 1973 and 1974 colonies were significantly different from each other ($p = 0.05$), whereas neither colony differed significantly from the 1960 colony.

I did not find any instances in which viable eggs were obtained from a female that did not have a spermatophore in the bursa. This is contrary to the findings of Benz (*1969*) but not unordinary as laboratory strains may differ considerably from one another.

After the third or fourth mating by a male, spermatophores were usually distorted in the manner described by Benz (*1969*) or Deseö (*1971*); however, the remains of the spermatophore could be distinguished when the female was dissected soon after death. In the case of the hard bulbous type of spermatophores, an extremely thin-walled spermatophore could be peeled away from the hard bulbous mass; whereas, in the case of the soft shapeless mass, the spermatophore was found as delicate shards, usually adhering to the wall of the bursa. In a third type of distortion, the spermatophore was extremely thin walled and delicate, and did not cause expansion of the bursa. When the contents of the spermatophore were evacuated, the bursa and the spermatophore within collapsed, leaving the bursa with a cup-shaped appearance. None of these distortions resulted in a reduction in the number of eggs oviposited or in egg fertility.

Table 2.--*Age of males in days and number of matings by colony at a given age*

Mating No.	Years of colonization	Age of males in days									
		1	2	3	4	5	6	7	8	9	Total
		No. of males mating									
1st	1960	41	12	1	1						55
	1973	35	15	1	1	1	1	1			55
	1974	49	7	2							58
2d	1960		36	13	5	1					55
	1973		28	18	4	1	1	1			53
	1974			43	10	3		2			58
3d	1960			27	17	3	1	1			49
	1973			23	15	8	1	1		1	49
	1974			37	12	5	2		1		57
4th	1960				22	15	1	2			40
	1973				20	11	3		3		37
	1974				33	10	4	2			49
5th	1960					16	8				24
	1973					10	11	1			22
	1974					24	7	3			34
6th	1960						8	1			9
	1973						4	4	1		9
	1974						11	2	1		14
7th	1960							1			1
	1973							1	1		2
	1974							3			3
8th	1960										
	1973										
	1974								2		2

There was a tendency toward reduced oviposition by females inseminated during later matings (table 3) in the 1960 and 1973 colonies, whereas oviposition in the 1974 colony decreased and then increased; however, I consider the data gathered after the fifth mating insufficient for drawing any conclusions. Deseö (*1971*), using a colony originating from the 1960 Yakima colony, found oviposition numbers to be independent of the number of preceding consecutive matings by the male; however, she did find that egg viability decreased after the third and fourth mating. My data for the 1960 colony showed no decrease in oviposition and viability until the seventh mating, and, as this is based on only one replicate, it has no validity. Hagley (*1974*) found reduced oviposition and egg viability resulting from matings with multiple-mated males. In the 1973 Yakima colony, oviposition but not egg viability was reduced after the fifth mating, but again, the replication is insufficient to draw any valid conclusions. This area of inquiry seems worthy of further investigation as oviposition and egg viability might serve as reliable indicators of colony strength with sufficient replication.

Table 3.--*Mean oviposition and egg hatch by colony and mating number*

Year of colonization		Mating number							
		1	2	3	4	5	6	7	8
1960	Eggs/♀	133	135	133	128	132	120	71	([1])
	Percent hatch	76	76	76	79	82	84	59	([1])
	No. matings	55	55	49	40	24	9	1	([1])
1973	Eggs/♀	130	140	131	116	117	105	84	([1])
	Percent hatch	72	79	77	78	77	77	73	([1])
	No. matings	55	53	49	37	22	9	2	([1])
1974	Eggs/♀	123	136	138	127	111	89	161	124
	Percent hatch	76	77	77	79	76	76	71	88
	No. matings	58	58	57	49	34	14	3	2

[1]No males from the 1960 or 1973 colonies mated more than 7 times.

Hutt (*1977*) reported on comparative recaptures of irradiated males from concurrent releases of moths of the 1973 and 1974 strains when they had been in the laboratory for 35 and 23 generations, respectively. Recaptures of males of the 1974 strain were significantly greater than recaptures of males of the 1973 strain. The measurements made in this test agree with those findings; however, since both colonies were measured at approximately 32 generations in colonization, the findings indicate that the 1974 strain is constitutionally stronger than the 1973 strain.

CONCLUSIONS

Some aspects of male biotic potential can be used as "vigor indicators." Total matings, mean matings per male, and the number of first, second, and third matings on days 1, 2, and 3, respectively, show significant differences, which can be correlated with other data (Hutt *1977*). Other parameters (table 1, 2, and 3), while not statistically significant individually, collectively show a trend in agreement with the statistically significant parameters and the field release of the 1973 and 1974 colonies.

LITERATURE CITED

(1) Benz, G.
1969. L'influence des stimuli externes sur la gametogenesis des insectes. Colloques Internationaux du Centre National de la Recherche Scientifique 189:175-206.

(2) Boller, E.
1972. Behavioral aspects of mass-rearing of insects. Entomophaga 17(1):9-25.

(3) Chambers, D. L.
1975. Quality in mass-produced insects: definition and evaluation. P. 19-32. *In* FAO/IAEA Panel Proceedings: Controlling fruit flies by the sterile insect techniques. Vienna, Austria.

(4) _____
1975. Quality control in mass-rearing. Annual Review of Entomology 22:289-308.

(5) Deseö, K. V.
1971. Study of factors influencing the fecundity and fertility of codling moth (*Laspeyresia pomonella* L., Lepid.; Tortr.). Acta Phytopathologica Acadamiae Scientiarum Hungaricae 6(1-4):243-252.

(6) Hagley, E. A. C.
1974. Codling moth: emergence, sex ratio, and abundance. Canadian Entomologist 106:399-402.

(7) Hamilton, D. W., and D. O. Hathaway.
1966. Codling moths. P. 39-54. *In* C. N. Smith, editor, Insect colonization and mass production, Academic Press, Inc., New York. 618 p.

(8) Hathaway, D. O.
1967. Inexpensive cardboard trays for mass-rearing codling moth. Journal of Economic Entomology 60:888-889.

(9) _____ L. G. Schoenleber, and L. V. Lydin.
1972. Codling moth: plastic pellets or waxed paper as oviposition substrates. Journal of Economic Entomology 65:1756-1757.

(10) _____ L. V. Lydin, B. A. Butt, and L. J. Morton.
1973. Monitoring mass-rearing of the codling moth. Journal of Economic Entomology 66:390-393.

(11) Huettel, M. D.
1976. Monitoring the quality of laboratory-reared insects: a biological and behavioral perspective. Environmental Entomology 5:807-814.

(12) Hutt, R. B.
1977. Codling moth: response to synthetic sex pheromone of two laboratory strains released in apples and pears. Environmental Entomology 6:666-668.

(13) _____ and L. D. White.
1972. Polystyrene toxic to codling moths. Journal of Economic Entomology 65:615.

(14) Hutt, R. B., and L. D. White.
1974. Codling moth: effects of 0 and 38 krad of gamma irradiation on the mating capacity of males. Environmental Entomology 3:645-646.

(15) _____ L. D. White, L. G. Schoenleber, and R. E. Short.
1972. Automatic collection of mass-reared codling moths by phototoxic response and a chilled environment. Environmental Entomology 65: 1525-1526.

(16) White, L. D., and R. B. Hutt.
1971. An inexpensive transparent holding cage for insect oviposition and longevity studies. Environmental Entomology 64:551-552.

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